SOIL CONSERVATION

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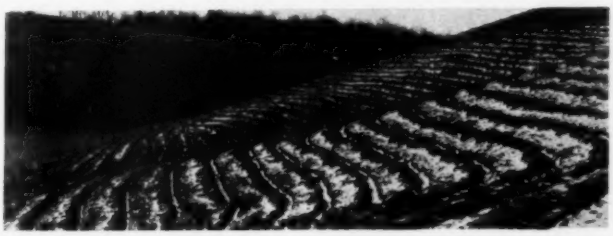

Steep slope in southwestern Ohio, contour-plowed in preparation for spring tree planting.

ANALYSIS OF TREE PLANTING PROBLEMS IN REGION 3

By G. Y. Bell[1]

DEFINITE standards for tree planting on private land are set up by the planting program of the Service. The most important problem is the selection of trees that will serve as cover to control erosion and at the same time yield other direct or indirect benefit to the individual farmer.

Tree planting is an essential feature of the soil conservation demonstration program. The very nature of the word "demonstration" demands that such plantings be successful. This is particularly true from the point of view of the farmer who may doubt that trees will grow when planted on what he considers a worn-out, worthless part of his farm. Successful planting on these poor sites requires the hardiest stock, careful thought regarding site preparation, and a thorough job in planting the trees. Planting plans must be worked out in detail because many small areas have a variety of soil conditions brought about by different degrees of erosion. Often it is necessary to use several species on an area as small as 5 acres. This is especially true if both sheet and gully erosion are present.

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Several controllable factors contribute to the success or failure of an erosion-control planting. Most important are: (1) Correlation of species to soil, climate, and other components of site; (2) determination of the practical need for and method of site preparation; (3) quality of planting stock; and (4) tree planting methods, tools, and crew organization.

Site factors to be kept in mind when determining species for a planting are the original soil types and their parent materials, the degree of erosion, present physical condition of the soil, and its ability to absorb and retain moisture, extreme temperatures, and amount and annual distribution of rainfall. Often, indicator plants such as broomsedge (*Andropogon virginicus*) and poverty grass (*Danthonia spicata*) actually growing on the ground are helpful in determining what to plant.

The importance of these factors is most commonly experienced when planting black locust, probably because of the extensive use of the tree, and present indications are that the selection of planting sites for locust should be as carefully detailed as for any other species. The important point in erosion control plant-

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Mulching with broomsedge on silt loam soil in western Kentucky, center (below man). Left, area sloped but not mulched. Right, area given no treatment whatever. Trees planted, spring of 1936. Unmulched plots replanted, spring of 1937.

ings is the analysis of the site and the selection of trees or shrubs which are most practical for, first, a quick vegetative cover and, second, an economic return to the farmer.

In some locations of western Kentucky and western Tennessee, for example that area lying between the Tennessee and Mississippi rivers, only 6 to 8 inches of loess soil remain on top of old Coastal Plain gravel and sand which is cemented to various degrees. Locust makes practically no growth on these areas. Where there is 12 inches or more of loess on top of the gravel or sand, however, locust will make excellent growth on sloping or gullied land. On some sheet-eroded areas locust does not grow well, even though there may be 18 inches or more of loess on top of the gravel.

Although the soils of western Kentucky and western Tennessee are similar there is a noticeable difference in the survival of trees which have been planted in the areas. Records for 1936 and 1937 show better survival on all species for west Tennessee than for west Kentucky. This difference in survival may be due to the difference in rainfall for the two areas in the summer months. According to the United States Weather Bureau records for the past 2 years, western Kentucky had 3 to 4 inches less rainfall than western Tennessee.

In southeastern Ohio, where more rain falls in the summer months than at any other time of the year, locust makes excellent growth on both sheet-eroded and gullied Belmont and Red Upshur soils. It also grows satisfactorily on some shales, and on phases of Muskingum soils.

The first important question in considering site preparation is whether or not any preparation is necessary. Thus far a great deal of labor has been put into temporary gully structures as means of site preparation and a much smaller amount into contour furrows, cultivation, mulching and fertilization.

Where it appears that site preparation is necessary, practical application should be observed and the cost figures obtained, and an analysis should be made to determine the practicability of the work and the method suitable for recommendation to the farmer.

Mulching, contour plowing, and the use of approximately 16 grams of a 2:12:6 commercial fertilizer to each tree are all practical methods which the farmer can apply himself. Computing on the basis of 1,200 trees per acre the fertilizer should not cost more than $1 per acre. Few farmers can afford to mulch unless they have the surplus straw, hay, fodder, or manure on the farm. Any farmer should be able to plow contour furrows in the fall or winter.

Every forester in the Service knows that quality of tree planting stock is vitally important. Experience for the past several years indicates that pine stock which usually does not become fully dormant during the winter in Tennessee will die if moved into Ohio and Indiana. The planting of 2:0 white, red, Scotch and Austrian pines in Ohio and Indiana is not satisfactory because of moisture requirements and vegetative competition. Transplant stock of these species brings about better results. Better results also are obtained north of the Ohio River with 1:1 or 2:0 shortleaf and pitch pines than with 1:0 stock.

Close-up of mulched area shown in companion picture, showing cover and locust trees.

Past unhappy experiences with poor grades of locust and pine have resulted in the setting up of definite standards for grades of nursery stock to be used in the future.

Tools used in Region 3 are the grub hoe, the planting bar, and the planting mallet.

The tree planting method is an extremely important factor for the success or failure of a plantation. In turn, factors which determine the planting method depend on soil conditions and rainfall distribution.

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SOIL CONSERVATION IN ANCIENT PERU

By D. R. Wickes and W. C. Lowdermilk[1]

THE terraces of Peru arrest the attention of the student of soil erosion. Conservationists may well ponder and study the agriculture of Peru in its development of crop plants and in the adaptation of sustained land use to steep, mountainous slopes. The value of land will have new meanings. Investments in the conservation of soils partake of an economy of survival rather than of scarcity or of abundance. And the herculean achievement of establishing a permanent agriculture or sustained use of land for cultivated crops in a forbidding mountainous area stands as one of the wonders of the world.

The beginnings of agriculture in Peru, probably some hundreds of years before the Christian era [2] may have been on lands recently aggraded by rivers in flood and left bare and ready for planting as water receded. However, it appears that most of the country up to the line of perpetual snow and ice was formerly occupied by forests, most of which were gradually destroyed by the inhabitants, though a few still persist.[3] The forested areas were probably first cultivated by essartage, the milpa system, which is still in use in the forested areas in the Amazon Basin. As there practiced, every 2 years a patch of ground is prepared by felling the smaller trees, leaving the larger ones standing. A great bonfire or series of bonfires is made as soon as the branches are dry enough to burn. The brushwood and tangle of creeping plants is thus destroyed, leaving the ground bare except for killed large trees. The vegetable ashes serve as fertilizer; and, after the ground is broken up with clubs, seeds or cuttings are dippled in with pointed stakes. The chief food crop is manioc (Manihot), though corn is much planted by some tribes. The ground will only carry two crops, and so a fresh patch must be cleared and broken up after the second harvest.[4] Whiffen says the disused plots are never again tilled for plantation, though in Central America they may be cultivated after the lapse of many years with restoration of forests in what amounts to a long rotation.[5]

But in the temperate or higher areas the slowness with which the forest is restored after cultivation of the soil would soon necessitate other methods, particularly in the event of an increasing or even stationary population to be maintained. In the absence of effective methods to prevent it, accelerated soil erosion

(*Continued on next page*)

[1] Dr. Wickes is library research worker, and Dr. Lowdermilk is Chief, Division of Research, Soil Conservation Service, Washington, D. C.

[2] Olson, R. L. Old empires in the Andes. Nat. Hist. v. 31, pp. 3, 4, 15. 1931; Cook, O. F. Staircase farms of the ancients. Nat. Geog. Mag. v. 29, p. 474. 1916.

[3] Cook, O. F. Agriculture and native vegetation in Peru. Jour. Wash. Acad. Sci. v. 6. 1916; Bingham, H. Inca land, p. 112, f. 145. 1922.

[4] Whiffen, T. The north-west Amazons. pp. 103–105. 1915.

[5] Cook, O. F. Milpa agriculture. Smithsonian Inst. Ann. Rept., p. 312. 1919.

BIBLIOGRAPHY ON SOIL EROSION AND SOIL AND WATER CONSERVATION.

Compiled by Stanley H. Gaines with abstracts by Francesca Vincent, Marion Bloom, and James F. Carter. U. S. Department of Agriculture Miscellaneous Publication No. 312. Washington, D. C., in press, October 1938.

This new bibliography, the most extensive on the subject in existence, represents a year of library research and much care and thought as to organization of material on the part of the compilers. There are 4,388 items, including references to both popular and scientific writings on soil erosion and the various phases of soil and water conservation. Some citations are included which refer to the writings of various authors on farming practices and conditions from colonial times to the present, but the large majority of the references point to literature in the English language which has appeared throughout the past 30 years in the United States and foreign countries.

The organization of the material is an interesting feature. Under the main heading "Erosion and conservation in general" are 1,164 citations, and following this is a list of 24 bibliographies, some of them extensive, which are likely to prove useful to the student looking for the available literature on all phases or any given phase of erosion and soil and water conservation. The remaining 3,200 references are divided into sections and placed under headings pointing out their relations to erosion and soil and water conservation. An alphabetical arrangement has been used for the listing of these sections—beginning with "Climate and physiography as related to soil erosion," through 18 special subject sections, and ending with "Woodlots."

A useful part of the bibliography is the List of Citations by Geographic Regions, placed conveniently at the front of the volume. The abstracts accompanying most of the citations are extremely valuable as time savers.—P. O'N. F.

Coming in November.—An article by Fred C. Newport and Robert R. Hinde, "Farming Level Terraces in the Dust Bowl."

The ruins of Machu Pichu, including the extensive irrigated terrace system. The ruins, abandoned for hundreds of years, are located in the valley of the Rio Urubamba, headwaters of the Amazon, about 50 miles northwest of Cuzco. The community constituted one of the farthest outposts of the Inca Empire in the jungles of the Amazon Valley.

would also almost certainly occur in these areas after the removal of forests and cultivation.

There is some evidence that following the removal of forests for cultivation this accelerated soil erosion actually took place. On the island of Titicaca, which was extensively cultivated in early times, the surface is described as largely covered with rocks and stones, with many boulders forming apparently an erosion pavement even in the better fields.[6] The immense deposits of alluvium in the valley of the Urubamba and other valleys of the Sierra may well have received contributions from the accelerated erosion which would almost inevitably follow the cultivation of deforested mountain slopes. The evidence that some terraces built on the mountain sides and along stream-beds were supplied with soil not from the slopes themselves but from elsewhere[7] tends to confirm the belief that serious soil erosion had taken place, in some cases at least, before the terraces were constructed.

During the Inca period, approximately A. D. 1000 to 1500, laws were made for the protection of remaining forests "where they were of any importance," and their cutting was restricted to the regions where the people were in want of fuel. "It was ordained that they should be cut in due order and license, according to the requirements."[8]

Potatoes may have been the earliest cultivated crop in the temperate parts of Peru, as they are indigenous to its coast and that of Chile including the slopes of the Cordillera de La Costa and have always been a source of food to the wandering aborigines in Chile.[9] Their culture spread very early through the uplands of Peru. They were probably cultivated there by groups who lived largely by hunting, at some time before the Christian era.[10] With the domestication of the llama a more settled life would result, and this combination of herding and potato culture still persists in the basin of Lake Titicaca and other highlands where corn will not ripen on account of the low temperature. In the temperate parts where climate is less severe, corn, which was very early introduced—perhaps also before the Christian era, likely from Paraguay by way of the Gran Chaco[11]—had practically taken the place of potatoes as an article of diet before the discovery of America by Europeans.[12]

The fertility of the alluvial soil in the valley bottoms, frequently renewed by deposits of mud from the streams in flood, must have encouraged the development of continued agriculture with crop production year after year on the same lands. The spreading of water from the streams on to land it would not otherwise reach, as was evidently done before the Inca times—probably A. D. 1000[13]—not only made it possible to raise crops during times of little or no rainfall but assisted in maintaining the fertility of the soil on those areas also. As population increased, more and more land was so irrigated, streams were narrowed and straightened by the construction of stone walls,

[6] Gregory, H. E. Geographical sketch of Titicaca. Bull. Amer. Geog. Soc. v. 43 p. 563. 1913.

[7] Cook, O. F. Staircase farms, pp. 475, 494, 496, 497. 1916; Garcilasso de la Vega, The Inca. First part of the royal commentaries of the Yncas, Markham's trans., v. 2, p. 4: "the rocks were removed and earth was brought from elsewhere . . ." 1871.

[8] Polo de Ondegardo, J. Rites and laws of the Yncas. Ed. by C. R. Markham p. 165.

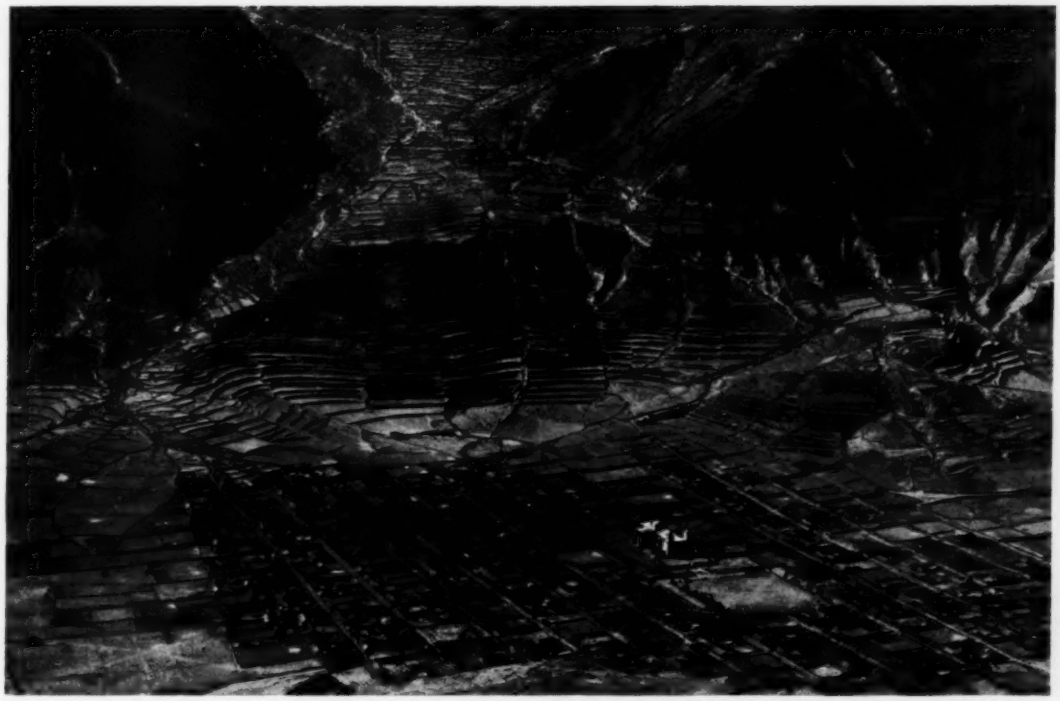
[9] Payne, E. J. History of the New World called America, v. 1, p. 312. 1892.

[10] Payne, E. J. op. cit. v. 1, p. 312; cf. Means, P. A. Outline of the culture-sequence in the Andean area. Proceedings 19th Internat. Cong. of Americanists, p. 237. 1915.

[11] Payne, E. J. op. cit. v. 1, pp. 326–329.

[12] Payne, E. J. op. cit. v. 1, p. 313.

[13] Avila, Francisco de. Narrative of the errors and diabolical rites in which the Indians of Huarochirí lived in ancient times, Ed. by C. R. Markham, pp. 144–146; Means, P. A. Biblioteca Andina, Part One. Trans. Conn. Acad. Arts and Sci., v. 29, p. 310. 1928.



A town in Peru, with terraced fields for the support of its inhabitants.

and terraces with stone retaining walls, likely used first in valley bottoms as a means of holding soil during floods, were extended farther and farther up the slopes.[14] Of the work of this period, O. F. Cook says: "At altitudes between 5,000 and 11,000 feet, agriculture was of the terrace system, which the ancient Peruvians carried to a higher development than any other people. The megalithic retaining walls, built of huge rocks, unsquared, but fitted together with precision, testify to a high degree of industry, organization, and skill, and must be reckoned among the chief wonders of the ancient world. Hundreds of square miles of land were reclaimed by straightening rivers, walling, filling, leveling, and covering with a deep layer of fine soil. All of these artificial lands had also to be irrigated, often by carrying the water channels for many miles through craggy mountains or along precipitous slopes. After being cropped with maize continuously for centuries the terrace farms are still fertile, and have enabled millions of people to live in a region that in its natural condition could have been of no use for agricultural purposes." [15]

Dillman S. Bullock considers that all of the land which could be irrigated was probably used by the Indians in the production of food crops before the coming of the Spanish about 1530.[16] Aside from the irrigated areas, large areas higher up which received more rainfall were also cultivated with fallow periods, but a considerable part of this land appears now to have lost its fertility.[17]

The conquest of Peru by the Spaniards must have brought great injury to the agriculture of Peru. The conquerors sought not for foodstuffs or ordinary crops, but for treasures with which they could enrich themselves and their country beyond the sea. Accordingly, aside from the large numbers of people who perished in the wars connected with the conquest great numbers were taken from their farms to work in the mines of Potosi and elsewhere. Others were forced to work on coca plantations in a climate to which they were not adapted, with the result that large numbers died. Diseases to which they were unaccustomed, brought in by the Spaniards and spreading rapidly, such as smallpox, tuberculosis and measles, also contributed to reduce the population.[18] It is generally

[14] Cf. Garcilasso de la Vega, op. cit. v. 2, p. 2, 4 f.

[15] Foot-plow agriculture in Peru. Smithsonian Inst. Ann. Rept., p. 487. 1918.

[16] Bullock, D. S. The agricultural situation in Peru, 1923. ms., photo. 219.

[17] Cook, O. F. Agriculture and native vegetation in Peru. Jour. Wash. Acad Sci., v. 6, p. 293. 1916.

[18] Popence, P. Proc. 19th Internat. Cong. of Americanists, 1915, p. 619; Forbes, D. Jour. Ethnol. Soc. London, v. 2, p. 198. 1870; Bingham, H. Inca land, p. 261. 1922.

agreed that during the early colonial period the population decreased enormously. Moreover, with this change of government, great irrigation works were allowed to fall into disrepair and ruin, decreasing the area which could be irrigated. Terraces in many places were abandoned and grew up to weeds or forest. The population at the time of the Spanish conquest has been stated to have been at least 10 million, some saying 20 million.[19] The census of 1862 gave a total of 2,487,916 and that of 1876, 2,699,106.

Sutton names three causes or accompaniments of the retrogression of agriculture and population since the 16th century: (a) a colonial policy based on mercantilism; (b) a policy of the Republican era based upon the same doctrine, exaggerating the importance of exports and neglecting the consuming powers of the home population; (c) the applying of standardized mass production and cheap labor to an industry characterized by the law of diminishing returns and requiring the most interested intelligence on the part of the individual worker.[20] He considered the population in 1929 to be not much more than half that at the time of the conquest.

Much land has continued to be cultivated, however, with the addition of various crops, notably wheat and barley, and by much the same methods as were used in ancient times, though oxen for ploughing have been introduced. Moreover, in recent years population has tended to increase, so that some have gone so far as to state that the number of Indians is probably now as large as it was before the Spanish conquest.[21] The total population was calculated by a committee of the Geographical Society of Lima to be 4,609,999 in 1896, and in 1927 it was estimated as 6,147,000. By far the larger part of the population is Indian, direct descendants of the Quechuas and Aymaras, who lived there under the Inca regime.[22] Ancient irrigating systems have been repaired, and the land is again being brought under cultivation.[23]

In 1925 C. W. Sutton was reported as estimating that there were approximately 1,000,000 acres (400,000 hektares) under cultivation in the coastal zone, and in the rest of the Republic a total of 1,800,000 acres (750,000 hektares) devoted almost entirely to products consumed locally (altogether, 1,150,000 hektares).[24] The figures published by the Ministry of Agriculture for 1929 gave the total cultivated area for the Republic as 1,463,867 hektares. Of crops, potatoes have the largest area, 285,274 hektares; and corn comes a close second with 280,412 hektares. Wheat has 142,154 hektares, and barley 124,806 hektares, cotton 126,883 hektares. No other crop approaches 100,000 hektares, though sugar has 77,987 hektares.

Thus, without iron implements, wheels or draft animals, without a knowledge of chemistry or of writing, the ancient Peruvians developed an agriculture which persisted through hundreds of years, mastered soil erosion, and is still continuing, with slight change, over considerable areas. In the domestication of potatoes they conferred a great benefit on the human race. They have left a remarkable example of success along with one of partial failure, in the cultivation of sloping lands. The failure appears to have occurred on lands not irrigated which became exhausted of certain plant foods essential to the production of crops. For intelligent industry, for solving problems in land use which we have not yet the temerity (or need) to undertake, for preventing soil erosion, and for the conservation of soil and water, the ancient inhabitants of Peru must be acknowledged as the first soil conservationists of the New World.

[19] Ugarte, C. A. Economic life of ancient Peru. Reprint from Inter-America, v. 8, p. 129. 1924; Sutton, C. W. Jour. Land and Pub. Utility Econ., v. 5, p. 372. 1929.

[20] Land economics and reclamation in Peru, p. 372. 1929.

[21] See Bingham, H. Inca land, p. 261. 1922.

[22] Bullock, D. S. op. cit., p. 8; Milstead, H. P. Distribution of crops in Peru. Economic Geog. v. 4, p. 88. 1928.

[23] Bullock, D. S. op. cit., photo. 219; Bingham, H. In the wonderland of Peru. Nat. Geog. Mag., v. 24, p. 490. 1913.

[24] Dunn, W. E. Peru, a commercial and industrial handbook, p. 98. 1925.

ANALYSIS OF TREE PLANTING PROBLEMS IN REGION 3

(*Continued from p. 90*)

The actual planting of the tree is the keystone of the entire program. Even though every step is correct to this point, improper planting of the trees may result in a plantation failure.

Certain points on how to plant a tree should be drilled into every individual tree planter during his first few days on the job. Failure to learn these essentials at the start may cause poor survival, poor growth, and sometimes the death of the trees several years later. Briefly these vital points are: (1) Depth to which the trees are set in the ground, (2) position of the tree roots in the ground, (3) condition of the soil placed around the trees, and (4) position of the tree after planting. Allotted space does not permit me to describe in detail the different methods of planting used in the attempt to place the trees in the ground in the most favorable condition for survival and growth. Every forester knows what these conditions are; the problem is to teach, to train, and to organize the men who do the work so that these conditions will be brought about.

TERRACES INCREASE YIELDS IN THE PLAINS

By Fred S. Reynolds[1] and Albert E. Coldwell[2]

MANY people have an idea that the Great Plains are practically level and do not need terracing for crop production. The fact should be borne in mind that water is the limiting factor in crop production on the Plains, that thousands of wet-weather lakes dot the countryside, and that these lakes receive their water from adjacent "level" land during rains. For clarification of this erroneous idea a survey was made on the Dalhart, Tex., project to determine yields and to measure the effectiveness of terracing and contouring in the area. A secondary objective of the survey was a comparison of the erosion-control value of vegetative covers found on the fields.

Yields of headed grain sorghums, for the 1937 crop year, were obtained on 63 fields. These included some fields that were under cooperation and others that were not. The height, density and kind of crop were recorded. Yields were obtained on 11,485 acres by taking 3,099 samples—1 to every 3.7 acres. The tables show results of the yield survey. The number of farms and acres are given for all comparisons. The larger the number of farms and the greater the acreage the more valuable the results obtained. The terraced fields in this study averaged one-half of 1 percent slope. None was greater than 1½ percent.

Table showing yields of headed grain sorghum on terraced, contoured, and straight-row fields on all except fields with sandy-type soils

Treatment	Number of fields	Acres	Average yields per acre
			Pounds
Terraced	20	4,226	720
Contoured	21	4,035	589
Straight rows	7	882	461

Comparison of the yields on terraced, contoured and straight-row fields clearly shows the advantage of terracing. The fact that 20 fields with 4,226 acres of terraced land averaged 723 pounds as compared to only 589 pounds for 21 fields of 4,035 acres of contoured land is a strong justification for terraces. The data on straight rows are limited to 7 farms of 882 acres with a yield of 461 pounds, which is still more convincing as to the advantage of terracing. Those who made the survey are of the opinion that the comparative relationship between the terraced, contoured, and straight-row fields would not have changed materially even if a much larger number of straight-row fields had been included.

Field observations showed that all the soils except the deep sandy types lost large quantities of water where contoured as well as where farmed straight. In contrast, terraced fields held and absorbed all the rainfall, and in numerous cases caught floodwater from adjacent areas to augment the rainfall. An excellent example of this is a terraced quarter-section of milo yielding 1,149 pounds per acre, which was flooded in May by run-off from adjacent fields. The four adjacent fields comprising 730 acres (two contoured and two with straight rows) produced from 236 to 506 pounds per acre, with an average of 307 pounds. All have the same soil type, received the same rainfall, and were farmed in a similar manner. The only factor of importance contributing to the high yield of 1,149 pounds was the terraces. Other terraced fields surrounded by unterraced ones showed similar results.

The straight-row fields, sandy soils excepted, were conspicuous by the spotted condition of their crops. The low spots where water pooled produced heavily, while the balance of the field was a near failure in most cases. On the other hand, terraced fields were remarkably uniform throughout, with the exception that the areas just above the terrace ridges were generally better than that below.

Table showing yields of headed grain sorghum on land terraced 1 year, compared with that terraced 2 years or more; including all soils except sandy types

Treatment	Number of fields	Acres	Average yields per acre
			Pounds
Terraced 1 year	6	1,696	636
Terraced 2 years or more	14	2,530	768

Since no moisture determinations were made over the terraced area, the probable reason for the difference in yields cannot be definitely ascertained. It is believed, however, that both the accumulation of soil moisture from year to year and the closer spacing of terraces contributed to the higher yield on the older terraces.

Those making the yield survey are firmly convinced of the advantages of terracing. It is our opinion that contouring is only a partial step in the right direction and that terracing should be vigorously pushed on all the soil types except sandy soils.

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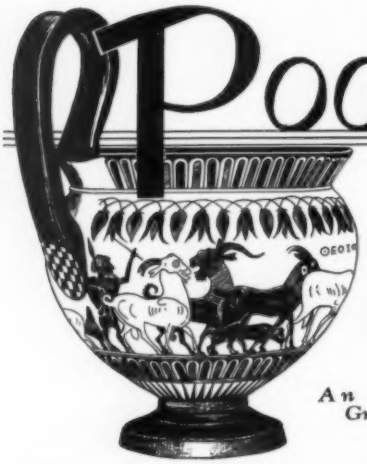
Poor Man's Cow

By Lois Olson



An ancient Greek vase.

THROUGHOUT Europe, conservationists from the Middle Ages to the present have regarded the goat as Public Enemy No. 1. No vegetation can escape the ravages of its sharp teeth and prehensile tongue; and its hoofs form beaten tracks, where run-off concentrates, or cut the vegetation and expose the soil to erosion. But, in spite of this, no other animal has been found that can replace the goat in the domestic economy of "the poor man." Three or four goats will supply as much milk as the average cow, and can be fed on half the cow's rations. A single cow supplies milk for only a portion of the year but with a few goats a farmer can maintain a constant milk supply for his family.

Nor is the goat merely a milk producer. Although goat meat is unpalatable, that of the kid rivals very young lamb in quality and the skin and wool of the goat have clothed the inhabitants of the semiarid lands since the dawn of history. Among the ancient Egyptians goat's wool was considered choice enough to be woven in mixture with silk and fine linen; and when the Israelites were returning from their exile in Egypt, their altar cloths and the curtains for the tent that housed the tabernacle were woven of goat's wool. Usually, however, the fleece of a goat consists of a mixture of hair and wool and, unless the two are separated, it can be used only for coarse fabrics, such as tenting, or for ropes and cables.

Note—The author is associate soil conservationist, Section of Climatic and Physiographic Research, Division of Research, Soil Conservation Service, Washington, D. C.

There is no record of the first domestication of the goat, but Central Asia is commonly regarded as its original home. When history began, they were well distributed over the known world. The kitchen-middens of the Swiss lake dwellers contain the bones of domesticated goats, and cuneiform records show that they were known to the Assyrians and Persians before 3000 B. C. Goats were found wild throughout the European highlands, and prior to the fourteenth century they were more common than sheep in the Scandinavian countries and the British Isles. Africa also abounds in goats, but the wild species are considerably smaller than those of Asia.

Goats were numbered among the riches of the Egyptians and, according to tomb records, one owner boasted the possession of 2,234 goats. Egyptian paintings depict herds being driven across newly sown fields to tread the seeds into the ground. So great was the prestige of the goat that, during the Second Dynasty, it was deified. Among the Hebrews the goat was a sacrificial animal, and the laws of Moses proclaimed its flesh "clean," and it could be used as human food. Rams, being aggressive animals, were selected to lead the flocks. In this connection the term "goat" or "he-goat" is used figuratively in the Bible to denote a "prince"—"Mine anger was kindled against the shepherds, and I punished the goats." (Zachariah X, 3.) In India the epithet *aja*, meaning "he-goat," was bestowed on certain deities, such as Brahma or Vishnu. The Libyan Jupiter had the horns of a ram and the Grecian Jupiter and Minerva are represented as wearing goat skins for their breastplates.

Pan was the goat-god of the Romans. He presided over shepherds and their flocks. But Pan gradually became confused with fauns and satyrs and changed his character from the beneficent to the malign. His mischievous pranks caused sudden fright among the country folk, and from this we derive the English word "panic." During the early Christian era Pan-like pranks were ascribed to the devil, and throughout the Middle Ages, Satan is represented as having the

cloven hoof of the goat. The significance of the cloven hoof continues—for the goat does "play the devil" with the land.

As long as the goat remains "the poor man's cow," the damage that it causes is almost negligible because the farmer with only a few goats seldom allows them to roam and graze promiscuously. The real danger develops when goats become a staple food supply, replace agriculture, or serve in lieu of currency. The Jews, who lacked means of refrigeration, were forced to rely on the smaller animals for their food supply. The fatted calf was killed only on special occasions, when the entire animal could be consumed at a single feast. The brother of the prodigal son complained that not even a kid had been killed in his honor. The effects of the ever-present goat are reflected in the eroded and treeless hills of Palestine, where once-famous forests are known to have existed.

During the Age of Pericles, Greece was at the height of her glory; but thereafter agriculture declined, and grazing, particularly of goats, increased. A large proportion of the forests had been cut down to build the navies that controlled the Mediterranean, farming had spread up the mountain slopes, and serious erosion was in progress. After rains, the run-off from the hills was rapid and the floods became higher and more frequent. The channels were blocked with sediment and the rivers, instead of flowing directly to the sea, overflowed the lowlands and covered them with debris washed from the hills or converted them into marshes. Much of the agricultural land could no longer produce crops at a profit and the farming population turned to grazing as a means of livelihood. Since Greece is mountainous, and since vegetation is sparse during the summer droughts, sheep and goats predominated. Goats are better climbers than sheep and can exist on a more meager food supply; where grass is lacking they browse on scrub vegetation, seedling trees, or even bark. As the pastures of Greece became poorer because of overgrazing, erosion became more widespread and the tendency to raise goats instead of sheep increased. In Greece the goats completed the task of forest destruction and their omnivorous appetites prevented forest regeneration.

The anopheles mosquito and the goat have always been allies. In Greece the goat increased erosion and run-off, and so indirectly provided the mosquito with more extensive swampland in which to breed. From the writings of Hesiod it seems probable that epidemics of malaria occurred in Greece as early as the Eighth century, B. C., but it did not become endemic until four centuries later—at the time of the shift from agriculture to grazing. According to Plutarch, the death of Pericles himself was caused by malaria. One by one the Greek states fell heir to malaria—even Boeotia, which had been renowned for its salubrious climate. Today, malaria is endemic throughout Greece and the hillsides support more goats than people.

Much the same story is repeated from Jerusalem to Madrid: "Forests given up to sheep and goats; forests destroyed, mountains devoid of life." In Cyprus, sheep and goats have almost replaced cattle, and the control of goat grazing in the forests has been one of the major problems of the British Government since its occupation of the island.[1] The importation of goats was prohibited by the forest law of 1881, and in 1913 a "goat law" was passed which enabled villages to decide by vote whether or not goats should be allowed within the village limits. In general, agriculture, particularly fruit growing, has improved greatly in exclusion villages. From 1914 to 1918 the problem of grazing was neglected, and all possible effort was directed toward the securing of wool in sufficient quantity to meet the requirements of the war. When efforts to restrict grazing were revived, and when applications for grazing rights were legitimately denied, protests and incendiary fires followed. It has generally been assumed that goatherds were poor men with no other means of earning a living if they were deprived of the use of the forests, but according to Unwin they are as a rule in better financial position than the average Cypriot peasant. Efforts are now being made to reduce the number of goats by giving their owners land with fruit trees, huts, and tools in exchange for goats. To date, however, the most effective method of reducing the number of goats has been through starvation resulting from the exhaustion of the pastures.

[1] Unwin, A. H. Goat grazing and forestry in Cyprus. London, 1928.

Italy and Spain also have large goat populations living on badly eroded pastures. In Italy it is recognized that the goat is an index of poverty, and recent legislation has levied taxes on goats in order to reduce their numbers and so end "la morte della montagna." To preclude unnecessary hardship, the poor farmer with only a few goats is exempt from taxation. Without restriction on goats it would be impossible for the Italian government to succeed in its campaign for the reforestation of critical mountain slopes. Regnault [2] attributes the serious overgrazing and erosion in Spain to the decline in population following the discovery of the New World and the consequent shift from farming to grazing. The flocks that were pastured in the lowland in summer and the plateaus in winter were everywhere granted the right of way during their migrations, and fences were prohibited. Rivers were turned into seasonal torrents and in Andalusia, as in Greece, malaria became endemic. Today the grazing of goats in the Spanish forests is prohibited, but the laws are commonly ignored.

Northern Europe began a war on goats centuries ago, and today the problem of goat grazing is almost negligible in most areas. Grazing in the forests is an integral part of the traditional forest rights or servitudes which originally developed to provide for the domestic requirements of the local population—but not for business purposes. As early as 1435, sheep and goat grazing was prohibited in the forests of the canton of Freiburg, and during the sixteenth and seventeenth centuries, most of the Swiss cantons forbade the grazing of goats in coppice stands of a minimum age, ranging from 5 to 12 years. According to a decree of the King, the royal forest of France was closed to sheep and goats in 1515, but the decree was never effectively enforced. The ordinance of 1669, passed during the reign of Louis XIV, limited the grazing rights of sheep and goats and similar restrictions were contained in the Code Forestière of 1827, but in the Alps and the Pyrenees any type of restriction met with open hostility. It has been estimated that within historic times the timber line in some parts of the Alps has been lowered 1,000 feet by overgrazing. In the various German states goat grazing was restricted by the earliest forest ordinances, but the problem was never as serious as in France and Switzerland.

Nowhere in Europe has the destruction caused by goats been as spectacular as on the Island of St. Helena. Goats were introduced in 1502 and multiplied rapidly. At first the overgrazing of the forest escaped notice because the goats fed on the young trees. The cumulative effects appeared suddenly when the older trees reached the age at which they normally died. In 1710 there were still good forest stands, but by 1724 most of the old trees had fallen and were replaced not by other trees but by grassland. Over a hundred years later (1836) Darwin commented, "Sandy Bay is nowadays so arid that it was necessary for me to see an official record to believe that trees had ever grown there."

In Africa there is less justification than in Europe for the continued existence of the huge herds of goats that destroy the vegetation and expose the land to erosion. Their meat is eaten by the natives only on ceremonial occasions and these have decreased in number since the introduction of Christianity. The milk is used only as food for children, and the skins are of such poor quality that they are seldom worth more than 6 or 8 cents apiece. Among the native tribes goats serve chiefly as a measure of wealth and for the purchase of wives to ensure to the head of the family sufficient progeny to maintain his prestige in perpetuity.

When land is first cleared it is used for cultivated crops with little thought of either maintaining the fertility or precluding soil erosion. After a few years of cultivation crops are no longer possible and the land is turned over to cattle. Much of the erosion caused by cattle is the result of inadequate water supplies. Cattle trails are formed leading to the watering places and around them the soil is badly trampled and the vegetation destroyed. As the land becomes too poor to support cattle it is turned over to goats who finish the process of destruction, and when they pass on to better pastures they leave behind a complete desert. When the ground has been bared, the goats reach upward for their food, and by standing on their hind legs can browse to heights of 5 or 6 feet. Near Lake Baring, in Kenya, Champion [3] noticed a line, like a flood line, some 5 feet from the ground, below which no green vegetation had survived. Unlike a flood line it undulated with the surface of the land; it represented the upward limit of goat grazing.

On foreign estates in East Africa the introduction of methods for controlling erosion is progressing rapidly, particularly in the English colonies and mandates. Crop rotation and mixed farming are common practices, the dairy industry is developing, efforts are being made to limit the stock to the carrying capacity of the pastures, and to some extent rotation grazing has been

[2] Regnault, Felix. The rate of depopulation, deforestation, and malaria in the decadence of certain nations. Smithsonian Institution Annual Report, 1914. Washington, 1915. pp. 593–597.

[3] Champion, A. M. Soil Erosion in Africa, Geographical Journal. 82: 120–129. August 1933.

adopted. Government subsidies and loans have also made possible an increased use of terraces and contour furrowing and the construction of erosion-control works.

The education of the natives is of necessity slower, but farming in general is improving under European guidance. But grazing is so ingrained in native tradition that no methods of curtailing it have been completely successful. To a large extent the erosion caused by native agricultural and pastoral pursuits has resulted from the establishment of the "Pax Britannica." In the past the number of the inhabitants and the size of their herds were limited by the ravages of warfare and disease. With this restraint removed both have increased rapidly in number and the land has suffered from overpopulation and overgrazing.

In South Africa, Angora goats have been introduced in the hope of improving the native strain and placing goat raising on an economic basis. Effort is also being made throughout East Africa to limit grazing by increasing the agricultural area. Although partially successful, it has been found in some areas that herdsmen have overgrazed the remaining pastures rather than part from their precious goats. Similarly, the sale of goats often has merely shifted the problem of overgrazing by increasing the size of the flocks in other areas. Cattle, even of inferior stock, can be used for meat extract, but not so with goats. If the quality and the value of goatskins can be improved, sale might prove effective, provided that the natives can be converted to the idea of wealth in the form of currency and savings accounts rather than of animals. Until this can be accomplished, efforts must be directed to the education of the natives and the improvement of pastures by regrassing, selective grazing, provision of more numerous watering places, reduction of burning, and the production of supplemental fodder supplies.

Since the Abyssinian War English writers have been much concerned about the effect on Egypt of the Italian ownership of Lake Tana, at the headwaters of the Blue Nile. Recently Newhouse [4] has suggested a more serious problem. "If Abyssinia becomes quiet and peaceful, and cattle and goats increase, the countryside will be torn to bits by torrents, the discharge of the Blue Nile will be a monstrous flood every year, and its whole regime altered to the certain detriment and possible ruin of Egypt." Unwin [5] struck a similar note in discussing the problem of overgrazing in Australia: "One cannot conjecture, without apprehension, what the result would have been had thousands of goats [rather than sheep] been allowed to graze * * *." It would most certainly have resulted in tragedy. And may it here be noted that the word "tragedy" is derived from the Greek word "tragos," meaning a goat's skin, which was the garb worn by the actors in the Greek Tragedies.

[4] Newhouse, F. Preservation of the Nile. The Engineer. 164: 624-625. 1937.
[5] Op. cit., p. 56

WOODY VEGETATION FOR FENCE ROWS

By Frank C. Edminster [1]

GENERALLY speaking, open land planted to farm crops or in pastures provides inferior habitat for the majority of wildlife species in the Northeast. This is particularly true of sedentary forms, including all farm game birds. While a few songbird species may find all their requirements within a single field, most birds and the larger mammals need a diversification of cover types in their seasonal habitats and a variety of habitat types in their year-round territory. It is true that variety in crops grown on a farm provides changes in habitat and that the margins are "edges" of a sort and are especially valuable when fields are strip cropped; but by and large, farm fields lack year-long shelter and are not secure in the major habitat attributes. Mowing, harvesting, grazing, or plowing will eventually remove most of the livelihood sources of the wildlife inhabitants.

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Acting as a windbreak and snow fence, interfield cover conserves soil moisture and reduces wind erosion.

Woody vegetation of one type or another, and swales and swamps, are the major types of permanent shelter found on farms in the Northeast. Properly distributed through the farmed land, they greatly enhance carrying capacity for most forms of farm wildlife. With "clean" farming and the utilization of all possible acres for crops, however, these shelter areas are generally not well distributed, because they are confined to land not farmable because of physiographic conditions. Or,

This contour fence overgrown with elderberry trees and blackberry bushes serves as a barrier to water erosion. The ground level on the upper side is 6 feet higher than that on the lower side.

we may say, as croplands are generally in contiguous fields, extensive acreages are devoid of adequate protective cover. This condition reaches its extreme development on the more fertile nad high-land-value farms and is progressively less marked on farms that approach the submarginal class.

Considering the possibilities of remedying the deficiency in wildlife shelter, we must accept the basic premise that although cropping methods may be changed, as from block fields to strip-cropped fields, lands now being farmed must continue to be cropped substantially as in the past. The one big opportunity for the creation of permanent shelter areas on cropped land lies in the revegetation of permanent field boundaries—the fence rows.

Fashion as much as anything has led farmers to subscribe to the dictum of clean farming—that is, bare fences and avoidance of weedy and shrubby vegetation. Based on the principle that such growth harbors pests inimical to crops, the practice of clean farming has also become a criterion of neatness. That the practice is detrimental to wildlife has not lessened its use.

Actually, overgrown fence rows, except where they contain alternate hosts of crop pests, are of benefit rather than detriment to crops. There are several reasons for this: They encourage birds which feed on insects and the seeds of weeds, and this assists in pest control; they act as barriers to soil erosion; they form windbreaks for the protection of crops and soil. In many instances, also, they furnish additional farm crops, such as berries and fence posts.

The problem is largely one of education. When it becomes stylish to have a dogwood hedge instead of a bare wire fence, there will be a dogwood hedge. When it is considered good farming practice to allow fences to overgrow, a man will be judged a good farmer when he does so. When the farmer has been shown the correct economics of brushy fences, it should not be difficult to change his aesthetic viewpoint. A fence row with foliage, flowers, and fruit certainly makes a more pleasing picture than does a stretch of galvanized wire. Other nations have learned the worth of such fences; Americans also should be awakened to an appreciation of a beautiful farm landscape.

I have indicated, in a general way, that the presence or absence of brushy fences determines to a considerable extent the wildlife population of the farm. Obviously this is true only in proportion to the extent and distribution of other permanent wildlife shelter habitat. The need for brushy fences, as far as wildlife is concerned, is primarily on farm lands that lack adequate woods, swales, and swamplands that are well distributed.

As a rule, fences will acquire a woody vegetation naturally where close cropping and cutting are avoided. For quicker results and to ensure the desired species composition, however, it is often desirable that fences be planted. This is particularly true of fences that lie on or approximately on the contour, and on land that needs soil-erosion control.

In choosing species of woody vegetation for fence-row planting, several factors should be considered. A brief outline of them is given below.

(1) Species which are tolerant of crowding, which form dense thickets and which have soil-holding root systems are desirable. Stoloniferous species are particularly adaptable in this respect.

(2) Species of low height growth, from 3 to 10 feet, are generally preferable to trees. Conifers are an exception, since they may be topped for Christmas trees when large enough.

(3) Species should be included that will furnish shelter to wildlife throughout the year.

(4) Species that will assure food for wildlife at all seasons should be given preference.

(5) Species furnishing fruit, nut and wood products for human use may be included where these are desired.

(6) Species resistant to grazing should be used on fences bordering pastures.

(7) Alternate hosts of crop pests should be avoided. In the Northeast these include red cedar, common barberry, gooseberries, currants, and buckthorn.

(8) Species poisonous to humans or livestock should be used with caution, or avoided entirely.

(9) Species selected should be adapted to existing conditions of soil and moisture, and should be light-tolerant.

(10) Native species are generally preferable to introductions from other regions, or exotics.

(11) The expense of close planting may be obviated by using species that reproduce quickly.

(12) Ideally, at least three types should be planted in each fence-row; one thicket-forming hardwood shrub, one vine, and one evergreen.

Brushy field fences are a means of conserving soil especially when they run across the slope. A recent (December 12, 1937) radio Farm Flash, issued by the Office of Information of the Department of Agriculture, cites a specific case illustrating this point. Referring to a farm in Kansas, it states that "like many other fields in the vicinity, [the] land was damaged by wind and erosion and the blowing soil piled up in drifts along the fence. Last year [the owner] observed that run-off water from his field backed up behind a large fence-row drift.

"This year his wheat yield ran 10 bushels more per acre on that part of the field where water was held by the drift. The fence-row drift had served as a terrace to hold water on his field where it could seep into the soil for plant growth."

This same principle applies to farms in the East, where water erosion is the main cause of soil losses. Cross-slope fences that are overgrown serve as barriers to both sheet and gully erosion and tend to form a terrace, which improves soil moisture conditions. In numerous cases there has been observed a 3- to 8-foot difference in ground level above and below the fence, largely owing to the building up of washed soil on the upper side of the fence.

The soil-conserving values of hedge fences have a direct bearing on wildlife since, like any other crop, it is basically dependent upon the soil. But the important aspect of the fence-row soil relationship to the wildlife manager and soil conservationist is that a sound program of farm wildlife management can be presented on a multiple-purpose basis. The direct agricultural benefits accruing from field hedges are more readily appreciated by the farmer than is the wildlife value alone. The encouragement of between-field permanent cover should be made on its complete multiple-value basis.

We have so far considered the farm fence as a means of obtaining permanent cover for wildlife on open lands and of improving soil conditions for farm crops. We may add that it also protects woodlands, swales, swamps, and water areas from livestock grazing. The effect of grazing on such wildlife habitats is too well known to need elaboration here. Too often, grazing renders uninhabitable to many species an area with great wildlife potentialities.

It should be noted that, contrary to open-land fences in relation to wildlife, the value of the fence in protecting woodland coverts tends to increase with the less fertile and poorer farm lands. Here, again, the arguments against the practice of grazing these inferior pastures are not confined to the advantages of encouraging farm wildlife. A sustained yield of woody products demands that woodland reproduction be protected. Proper conservation of farm soils and water is impossible without protected permanent vegetation in woodlands, gullies, swamp, and marsh areas. The wildlife program must be constructed on this multiple-purpose foundation if it is to be practical and successful, and the use of the fence as a tool of the conservationist should be given greater attention than ever before.

EROSION PROBLEM CONFRONTS HAWAII

By N. E. Winters [1]

SINCE the voluntary annexation in 1898 of the Hawaiian Islands to the United States they have developed rapidly in industry, agriculture, and commerce. Our largest army post under one command is located on the Island of Oahu about 22 miles from Honolulu, a modern city of nearly 150,000 inhabitants.

When the English explorer, Capt. James Cook, discovered the Hawaiian Islands in 1778, he found them inhabited by approximately 400,000 Polynesians. They were happy and carefree, needing only grass huts for shelter and grass skirts for clothing. They lived by fishing and a very primitive form of agriculture. Under a balanced diet of fish, breadfruit, taro, nuts, and fruits, they were a good natured race of wonderful physique. Like the American Indians, the Hawaiians had difficulty in adjusting themselves to changes in the social and economic order brought about by the coming of the white man. They had a strong disinclination to hard manual labor, so that the planters found it necessary to import laborers from various countries.

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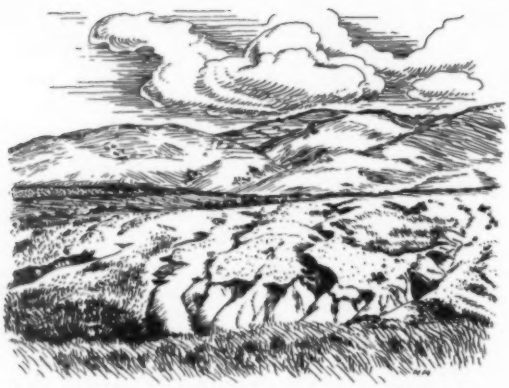

Abandoned pineapple field in Oahu south of Schofield barracks. Most of the soil is gone from this field.

Between 1852 and the annexation to the United States, laborers were imported from China, Japan, Puerto Rico, Philippine Islands, Norway, and the United States. Most of the unskilled laborers came in under contract to work for a period of years at stipulated wages and hours.

The first missionaries from New England landed near the Kona Inn on the Island of Hawaii in 1820 and several boatloads followed during the next 40 years. The entire life, including agricultural and social development of Hawaii, has been profoundly affected by these sturdy pioneers and their descendents who are now among the principal financial, agricultural, industrial, and educational leaders of the Territory.

Of the present 400,000 population only about 6 percent are pure Polynesian and 8 percent are mixtures of the Polynesian blood with whites and other races. Approximately 22 percent belong to the white race and some 55 percent are Orientals. There is an average of 57 people per square mile, the population being very unevenly distributed. Thirty-seven percent of the people live in Honolulu. Hundreds of square miles in the mountainous sections are uninhabited, while the rich agricultural sections are densely populated.

Wailua Falls, eastern slope of Kauai.

The first sugarcane plantation was established at Koloa on the Island of Kauai in 1835. Before these plantations got under way most of the farming operations were conducted on a small scale, but during the last 50 years large sugarcane plantations have demonstrated their ability to cope with the problems of production and marketing and to give better returns on investments than did small farms working independently. At present 39 sugar-producing corporations operate under the direction of 6 cooperating agencies who are members of the Hawaiian Sugar Planters Association. The association founded an experiment station in 1895 and now has a staff of 100 scientists and an annual research budget of half a million dollars.

View of erosion in Hoolehua pasture of Hawaiian Homes Commission.

Since 1900 the pineapple industry has attained stabilized production and marketing by means of large companies working in cooperation under the corporation known as the Pineapple Producers' Cooperative Association, Ltd. This industry employs about 25,000 people in the Territory. The pineapple producers also have a well-organized experiment station. Through this corporation, agricultural and industrial leaders in Hawaii have developed a high degree of efficiency in the production and marketing of both sugar and pineapples. The annual revenue from these two crops approximates $150,000,000.

Erosion is not so general and widespread in the Territory as it is on the continental United States. The geologic youth of the islands, and the tendency

Incipient gully formation on pasture land of Lanai with clumps of Natal grass.

toward a lateritic soil development over basaltic volcanic lava rock, cinders, and ash, has resulted in rather permeable soil and rock conditions which are more or less resistant to erosion, especially in the areas of heavy rainfall. Over 70 percent of the cultivated land produces sugarcane which, when well established, is a good erosion-resistant crop.

The most serious erosion is found in clean-cultivated fields where pineapples and other row crops are produced. Approximately 22 percent of the cultivated area produces pineapples and about 6 percent produces other crops, most of which are not resistant to erosion. Some 25,000 acres are plowed and fallowed each year in preparation for planting sugarcane. During this period of preparation and before the young cane becomes well established, especially on steep slopes, large quantities of soil may be washed from the fields by the heavy rains which are characteristic of the Territory.

Incalculable losses of soil from both wind and water erosion have occurred on pasture and range lands where grasses have been destroyed by overgrazing, and where the original valuable forests have disappeared under exploitation.

The progress of civilization during the last 150 years has in many parts of the islands had an effect similar, in the exploitation and destruction of the great natural resources of soil, range grasses, and forests, to that found on the mainland.

The Territory of Hawaii is in the hands of capable and intelligent leaders who have watched the clouds of dust as they blow out into the Pacific. After heavy rains, they see their precious soil washed down to fill up their fishponds with erosion debris and to darken the waters of the ocean. These leaders are fully awake to the menace of erosion and are ready to cooperate in a control program of well-planned and practical research and field operations.

Dust-Bowl Experience with Strip Cropping

By R. R. Hinde[1]

STRIP cropping, an accepted practice in areas of high rainfall, likewise has established its value in controlling wind and water erosion in the semiarid Great Plains region.

Twenty-six demonstration project and camp areas and nine conservation districts in Region 6 reported a total of 91,909 acres of strip crops in 1937. Included were cotton, corn, beans, summer fallow stripped with sorghums, and small grains.

Soil blowing became serious in the central part of the Great Plains area 5 or 6 years ago. It is assumed that drifting will remain a problem as long as a summer fallow system prevails.

Depletion of crop residues and trash because of drought and resultant wheat failures has convinced farmers that they must change their methods to produce profitable yields. This realization has led to emergency measures which are inexpensive and otherwise practical. Many farmers have turned away from summer fallowing and wheat growing and are now planting their fields solid to sorghums in order to regain residues or trash for stabilization of the soils.

In 1936, farmers who had grown good grain and forage sorghum crops the previous year were prepared to start strip cropping. In the Dust Bowl, however, there was little experience or experimental data on which to start a strip-crop program. Ideas varied as to width of strips. Patterns ran from alternate plantings of 2 to 68 rows of sorghums for protection of fallow spaces as wide as 200 feet.

In areas of straight grain farming a practice now proved to be effective consists of alternating summer fallow and grain in strips of equal width. Where the land is fallowed every third year instead of every second year, grain strips are made twice the width of the fallow. Width of strips are regulated to suit

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available farm machinery, but are kept on the contour.

A farming system which is becoming popular in western Kansas and eastern Colorado is the sorghum-fallow-wheat combination. In this, sorghum is rotated in the strip one year, followed by fallow the next, then wheat. Fallow, coming immediately after the sorghum, reduces the wind erosion hazard usually present when fallow follows wheat because sorghums supply the soil with adequate residues.

Width of sorghum strips depends upon the farmer's forage needs, but as a general rule a field is divided to a third each of sorghums, fallow, and wheat. This cropping system better balances farming operations, provides diversification and includes the yearly production of livestock feed.

This system enables the farmer to know each year the acreage he will have in crops and in fallow. Flexible or variable cropping is possible. For example, if moisture and residues are favorable in the fallow strips at planting time, wheat may be seeded. If conditions are favorable for such planting, fallowing should be omitted, with sorghums being planted solid at the first opportunity the following spring.

Strip cropping of fallow is subject to certain precautions. The surface soil ought to have ample residues or trash which can be conserved by cultivation. Certain tillage implements used for seedbed preparations encourage soil blowing more than others, especially during summer cultivation. Preferably, plowing and other cultural operations should be done only when the soil is moist. A cloddy surface breaks the ground sweep of winds and reduces soil drifting. Implements should be selected according to their efficacy in producing clods and incorporating crop residues in the surface layer.

In most of the Dust Bowl, with the exception of certain parts of Colorado, eroding winds come from various directions. Contour operations, therefore, are for reducing water run-off.

Border plantings at the edge of a field fit well into the strip-crop system. They furnish double protection to crops by retarding run-off water and by checking the spread of soil drifting from adjacent unprotected areas.

Such border plantings usually are seeded with a grain drill or broadcast seeder. The strips should be wide enough to permit the turning of implements and to prevent plowing or cultivating into the terrace outlets.

There is little experimental data on which to base the width and frequency of strips used for wind and water erosion control on any given slope, soil type or field subject to erosional losses. The width of erosion-resistant strips in relation to the width of erosion-nonresistant crops is determined by the erodibility of the soil, wind velocities, slope, and character of rainfall. For these reasons, it is recommended that about one-half of the field area be planted in strips to an erosion-resistant crop. Densely-growing feed crops such as sorghums, small grains and cultivated grasses are of proved usefulness for these control strips.

In the High Plains area strip cropping, plus terracing, is believed to be even more effective than strip cropping alone. This is because terraces increase favorable planting opportunities through conservation of run-off water.

Strip cropping alone is not enough. It is a practice which fits naturally into a variable cropping system with contour tillage operations and cultivation along the terraces. Observations in the Dust Bowl indicate that erosion-nonresistant crops such as corn, beans, and potatoes should be planted in strips of 4, 8, 10, or 16 rows, alternating with strips of sorghum or small grain of as many or more rows. Cotton, when grown on the lighter textured soils, should be planted in strips of from 20 to 30 rows, alternated with sorghum in strips of not less than 10 to 15 rows. On heavier textured soils, strips of cotton may be as great as 40 rows in width, alternated with strips of sorghum of 15 to 20 rows.

Observations show that varying heights of stubble play an important part in reducing soil blowing. There are several forms of soil movement. Among them is the dust cloud of very fine particles which rise to great heights and are carried long distances by air currents. Another is the stratum of heavier particles billowing along 5 to 10 feet above the ground. These particles settle rapidly as the wind velocity diminishes. A third important type of soil movement involves larger particles swept along not more than a foot or two above the ground. These particles cut off vegetation, scour the surface soil to form fans, pockets and hummocks, and contribute to the formation of dunes on the sandier lands.

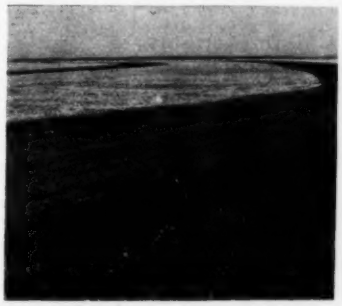
To reduce soil blowing, some farmers of the Dust Bowl are using alternate strips of grain and forage sorghums in a strip-crop pattern. The forage sorghums are planted in an equal number of rows of equal width, alternated with strips of grain sorghums of the same number of rows. Forage sorghums usually are cut with a row binder, leaving stubbles from 4 to 8 inches high. Grain sorghums are hand-headed or combined, leaving stubbles from 2 to 3 feet in height. This system, used for the protection of cotton, beans, or fallow, has been found very effective in reducing erosional losses.

Many farmers in this area are using strip cropping to control wind and water erosion and at the same time are making profitable yields of crops.

Strafuss and Son have solved the wind erosion problem on their farm north of Hereford, Tex. When dust storms started in 1933, these farmers realized that a change in the usual wheat tillage methods was necessary. Since that time they have planted wheat in contour strips approximately 170 feet wide, alternated with equal width strips of the previous year's wheat stubble. The following year, these strips of stubble are summer tilled in preparation for the next wheat crop. These farmers have experienced only one complete wheat crop failure during the drought period, which they attributed to damage from soil drifting from adjoining, unprotected fields. They hold the opinion that wind erosion can be reduced to a minimum only through the concerted efforts of all farmers in the area.

George P. Turrentine, a cooperator of the Soil Conservation Service project at Hereford, Tex., is another farmer who is using strip cropping with success. His section of land was broken out in 1927 and was farmed to wheat continuously until 1936. A survey after the 1936 "blow season" revealed that 20 percent of the topsoil had been removed from Turrentine's field. In the Spring of 1936, he planted grain sorghums in a strip-crop pattern. The average width of the sorghum strips was 65 feet, being alternated with 105-foot summer fallow strips on the contour. The fallow strips were kept free of weeds during the summer by the use of a one-way and rod weeder. Wheat was planted in the fallow strips after a 4.13-inch rain late in September. Tests at the time of seeding showed a moisture penetration of 32 inches. Mr. Turrentine harvested and sold $2,200 worth of milo maize from the sorghum strips, and the yield from the wheat strips was 15 bushels to the acre.

Strip cropping of sorghum, fallow and wheat also has given excellent results on the Soil Conservation Service project area at Liberal, Kans. In 1936, Dan L. Jantzen, who lives 16 miles northeast of Liberal and on the project area, strip cropped 160 acres. Strips of milo were planted on the terrace lines, alternated with strips of summer fallow. The milo strips were approximately 65 feet wide with fallow strips 150 feet in width. At planting time in the fall of 1936, moisture penetration in the fallow was 36 inches. Jantzen's wheat yield was 18.8 bushels to the acre, while an adjoining field which was summer fallowed and farmed in the conventional manner produced 9.3 bushels to the acre.



Strip cropping of sorghum, fallow, and wheat is practiced on the 160-acre farm of Dan L. Jantzen, 16 miles northeast of Liberal, Kansas. Jantzen harvested 18.8 bushels of wheat per acre in 1937, largely as a result of using soil and moisture conservation practices.

These comparative yields furnish evidence of the value of soil and moisture conservation by tillage operations and of the protection furnished by strips.

Louie Lembert, another cooperator of the Liberal project, strip cropped a 100-acre field, half to sorghums and half to fallow. After harvesting a ton and a half per acre of grain from the sorghum strips, Lembert seeded wheat in the fallow strips on September 14. The moisture penetration on December 11 was 57 inches. Lembert harvested 19.4 bushels of wheat to the acre while an adjoining field, not farmed on the contour or strip cropped, showed a moisture penetration of 19 inches in December and failed to produce a wheat crop.

Two brothers, Boyd and Carson Echols, operate a farm 8 miles east of Lamesa, Tex., in cooperation with the Soil Conservation Service C. C. C. demonstration camp. They planted grain sorghums on the terraces with alternate and equal width strips of Sudan grass and cotton in the terrace intervals. Their yields were a ton of grain sorghums and half a bale of cotton to the acre. The Echols brothers state that these yields are more than the farm had produced in the 6 previous years. Conservation of moisture by terraces and contour tillage was responsible for holding rainfall on the field for crop use, while the strips furnished protection against soil blowing.

The farm of S. L. Eason, a Soil Conservation Service cooperator residing 6 miles west of Abernathy, Tex.,

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Some Maryland Farms Gone Downhill

By Angus McDonald[1]

IF YOU want to see a graveyard of farms go out to the Soil Conservation tract [2] near Beltsville. The old men will tell you that where there is nothing but deserted homesteads and old fields grown up in pines there were once prosperous plantations. They do not remember but they know because their fathers told them.

I went over this land with Thomas Taylor, a farmer in the neighborhood, who knows the old landmarks and plantation sites.

We walked along an old abandoned road up a hill through the woods of pine, white oak, and blackjack. "Now", said Mr. Taylor, "I will show you one of the old plantations." We reached the hill-top. "Look!" he said. There was a little clearing on the hillside and nearby some old abandoned outhouses. Standing like a monument was a huge chimney with two fireplaces, one for the first story and one for the second. The house was gone, carried away or torn down. From where we stood we looked across a little valley to a ridge half-a-mile beyond. The valley disappeared in the rise of trees on either side. I could see there was only scrub timber: dense undergrowth in some places, vegetation part green and part dead, the oak, the blackjack yellow, the pine green. There was no sign of any human habitation, no cleared or cultivated land as far as the eye could see. "This was once a prosperous plantation," said Mr. Taylor. "In the valley there before the Civil War there was a well-kept meadow next to a large apple orchard. Most of the land was in cultivation—corn, tobacco, and wheat. Here is where the old slave houses were. You can see the foundations. The big house was here. Over there, a few hundred yards away, was a schoolhouse long since burned down. Let's walk over the place a little."

Down the hill a little way was a spring from which flowed a brook that wound its way into the valley. We followed one of the old roads down the hillside. Nearby was a gully, once a road, worn 5 or 6 feet deep and long abandoned.

"See the old corn rows," said Mr. Taylor. "This land must have been abandoned 75 years ago." The ridges were so slight you could hardly see them. Here and there were fallen decayed trees, burnt stumps, and other signs of fire but covered over-all with a growth of scrubby timber. In some places it was so thick you couldn't walk through it. Over all the place hung an air of the past. One had the feeling that in spite of the greenness of the woods, there was decay: that the job of agriculture was somehow botched and that Nature, ashamed, was trying to cover it up.

"Why was this land abandoned?"

"Well, you'd have to go back a long way, I guess, to find that out. There are many reasons. A lot of the other farms are in the same fix. This is the worst one."

A long time ago, almost 250 years, Indians hunted and roamed over this land. But the English settlers, ambitious and aggressive, pushed up the rivers, clearing the best land, pressed the Indians back, and put their slaves to work in the wilderness, building homes, and raising tobacco.

One of these hardy pioneers was a Scotchman, an indentured servant, who gradually acquired thousands of acres of land in Prince Georges County. A great hulk of a man, 7 feet tall, was Ninian Beall. He became known as a fearless Indian fighter and was a colonel in the provincial army. He was the first to patent land on what is now the Soil Conservation tract. He took up 400 acres called "Recovery" in 1704. Others followed him slowly. Some of the land was thin and barren but the less sterile parts were patented by 1750.

By Revolutionary times the Tylers, the Duvalls, the Brashears, and the Crosses were settled in the neighborhood. They put in crops of tobacco and corn and impoverished the land. Their slaves cleared new land in the winter as the old fields became worn-out. Joseph Cross, a lieutenant in the Revolution, settled on the place Taylor had pointed out to me. In 1783 he married Lucy Brashears, a descendent of Samuel Brashears who had patented "Brashears Pocosin" in 1717.

By 1825 land in Prince Georges that would raise good tobacco was scarce. The young men moved west as their forefathers had done. But some of the old settlers wanted to stay so they set about to find some way to build up the land. They had heard of

[1] Erosion history unit, Soil Conservaton Service, Washington, D. C.

[2] Seventeen hundred acres located in the northern part of Prince Georges County, Md.

Edmund Ruffin of Virginia. He had done wonders with marl. Other men had used lime and fertilizers of various kinds, and for the first time, after a century of neglect, the land received some consideration. Since 1800 Maryland had been a scene of desolation, old abandoned fields on every side and the land impoverished and worn-out. But the lime users changed this.

Horace Capron settled near Laurel and Charles Calvert near Riverdale. They began to bring the sterile land to life and the Beltsville people took notice. Alexander Keech and William Hall, who lived on what is now the Soil Conservation tract, learned from these men how to make farming pay: more feed crops, lime, marl, stock manure and less tobacco.

The Cross and Hall plantations flourished and the community grew in prosperity and population. Then the Civil War came and the whole agricultural economy was upset. After the war prices fell and labor became scarce. The land in the Soil Conservation tract was never very good; it slipped down below the marginal line and became submarginal. Some of the old settlers left but most of them stayed. The nearby city of Washington was growing and some of them got jobs there, using their homesteads as residences.

And the forest, always fighting against the farmer, began to close in on the cultivated areas little by little. Once there had been good forest on the land—big trees that were good for lumber, houses, and wagons. But the forest could not come back to what it had been. Every 10 years or so fires came. They killed the large timber, destroyed the small, and made natural selection impossible. A few men continued to farm. They raised vegetables and sold them in Washington, but they needed little land for this and once the forest got the land it kept it. It cost too much to clear it—more than it was worth.

One man tried large-scale farming and failed. He farmed on the north side of the tract. Another man, Thomas Taylor, my informant, moved on the land in 1908 and was successful. His farm was on the south side where some of the land was better. He manured, limed, raised livestock, and worked from morning to night improving. "I showed these farmers how to farm," he said. One year he put 3 tons of lime to the acre on one plot of ground. "What a crop I made. A lot of this is all right if it is treated right but it takes work—more work than it's worth. I figure if a man hired this land cleared, cleaned, and the stumps pulled, it would cost $350 an acre."

Again I walked over this 1,700 acres and I saw more abandoned farms—some of them abandoned years before the Government got the land. Houses falling down; some of them burned with the massive chimneys sticking up like monuments.

On one of my walks I stopped at a house where someone was living. A hound dog was tied to the front porch. An old man came out and talked to me about the land. Yes, he knew that land. It had been good land once. "My grandfather owned six plantations around here. He was a rich man and made a go of farming. Come into the house and sit down." There were blankets on the windows because the glass had been broken out. When my eyes became accustomed to the darkness I looked at the room. It was filthy; there were dirty dishes on the table and a dog on the bed. The old man lived alone and did his own cooking. He had lost his land and was living in a house not his own.

"Why was this land abandoned?" I asked him.

"It cost too much to work it. It wore out; some of it washed away. We couldn't make ends meet."

"Why didn't you lime it? Improve it in other ways?"

"That takes money. We couldn't make ends meet. We got poorer every year. You know it's funny about this land. My folks owned it a long time. When a person loses his land he loses about everything, I guess." And he looked around apologetically at the room.

EXPERIENCE WITH STRIP CROPPING

(Continued from p. 105)

provides another excellent example of the value of strip cropping. During the 1936 "blow season," soil drifts 6 inches high were formed on a portion of Eason's field, and 3 inches of topsoil were removed from another portion of his land. In the late winter of 1936, Eason constructed level terraces and blank-listed his field with the terraces. In the spring, strips of Sudan were planted along the terraces and the intervening spaces were planted to cotton. Eason harvested 368 pounds of lint cotton to the acre while an adjoining field, farmed without strip cropping and terracing, yielded only 110 pounds to the acre.

L. A. Harral, another cooperator at Littlefield, operates a 1,400-acre farm. In 1937, he harvested three-fifths of a bale of cotton and a ton of milo to the acre from his terraced and strip-cropped field.

Last year, Mrs. Ruby Davis, cooperating with the Soil Conservation Service camp at Lamesa, Tex., strip cropped and terraced a 59.8-acre field with cotton and milo, and planted Sudan in border strips as A. A. A.

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BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

LANDSLIDES AND RELATED PHENOMENA: A STUDY OF MASS-MOVEMENTS OF SOIL AND ROCK. By C. F. Stewart Sharpe. Columbia University Press. 1938.

We all know of Dr. Sharpe as a research scientist in the Section of Climatic and Physiographic Studies of our own Service, and it is most gratifying to know that his book has turned out to be a work of some distinction. Furthermore, and aside from this, the book should be studied carefully by soil conservationists for a better understanding of topographic and soil conditions—for foresight in soil conservation practices, especially structures planned to control erosion on slopes or wherever the soil and rock have the tendency, from this or that cause, to slip downward.

Geomorphologists are greatly interested in Dr. Sharpe's new classification of mass movements as based on kind of movement and relative rate as the primary factor, water or ice content of the moving mass as secondary, and the composition of the moving mass itself as third. In fact, the half-title page of the volume designates it as No. II of the Columbia Geomorphic Studies, edited by Douglas Johnson, who is professor of Physiography at Columbia University. No. I was Douglas Johnson's own work, Stream Sculpture on the Atlantic Slope.

The four main headings used in the new classification are slow flowage, rapid flowage, sliding, and subsidence. Rock-creep, talus-creep, soil-creep, rock-glacier creep, and solifluction are classed under slow flowage. Of these phenomena, soil-creep is most significant from the standpoint of soil conservation on agricultural lands; creep is accelerated by deforestation and unwise land use. The rate of creep, which depends on soil type, slope, climate, etc., is at a minimum in loess and pronounced in loose soils. Soil-creep is more rapid in partly saturated soil, slower in arid soils, and is often very rapid (even to debris-avalanche movement) when soil is completely saturated owing to protracted heavy rains.

In his discussion of the causes and the observable evidences of soil-creep, Dr. Sharpe's own careful and rather extensive field studies are indicated. Common evidences described and illustrated are: Displaced posts, poles, monuments, walls, and foundations; curved tree trunks concave upslope; the "stone line" at the base of the B horizon of creeping soil on slopes; roads and railroads out of alignment; turf rolls downslope from boulders. As to causes of creep of the soil mantle, these are separated into two orders—(1) topographic, structural, climatic, etc., conditions favoring creep, and (2) active causes such as weathering agents, load increase, filling and closing of cavities, wedging and prying by roots and animals, and expansion due to freezing water in crevices, to heating and to wetting and swelling of colloidal matter. All causes of creep are brought together in a convenient list at the close of the chapter "Slow Flowage." Of special interest in this part of the book is the discussion of indirect downslope movement caused by frost heaving. An excellent photograph is shown of frost crystals, or needle ice, with the earth and pebbles raised 2 inches and falling downslope as the crystals melt at the base. Under the main title "Slow Flowage," talus-creep, rock-creep, solifluction, and rock-glacier creep, receive considerable attention. Here, as throughout, the author has summarized the significant literature on the subjects and excellent diagrams show the typical relations of talus-creep and soil-creep, frost action and solifluction, and winter talus ridges. As to talus-creep, we learn that the phenomenon is common wherever steep talus exists; that rate of movement depends on climatic conditions and is most rapid in cold regions, as subarctic and above timber line, where there is alternate freeze and thaw in the interstices of rock waste. This type of creep is slower in warmer climates but is appreciable and easily determined over a period of a few months. In humid climates, wind, rock disintegration and drainage cause talus-creep. Addition of material at the top of a talus always accelerates talus-creep.

Earthflow, mudflow, and debris avalanche are types of rapid flowage, and chapter 4 treats of these intermediate mass-movements. Earthflows occur on gentle slopes with slippery clay beds, while mudflows, which are more rapid because of higher water content and steeper slopes, usually follow stream courses and are often caused by absence of substantial vegetative cover on unconsolidated material. Dr. Sharpe gives interesting accounts of historical mudflows and classifies mudflow types as semiarid (caused by denudation and torrential rains), alpine (the result of snowmelt and sparse vegetation), volcanic, and outflow or "bursting" of bogs.

Dr. Sharpe describes debris-avalanche as "a flowing slide" the initial movement of which is caused by slippage. Debris avalanche is almost always preceded by heavy rain, increasing weight, and lubrication, and may occur in humid areas well covered with vegetation.

The author defines a landslide as "the perceptible downward sliding or falling of a relatively dry mass of earth, rock, or mixture of the two." Types (slow to very rapid) are slump, debris-slide, debris-fall, rockslide, and rockfall. Slumping is discussed at length as significant, along with soil-creep, in agricultural areas. Slumping is responsible for the development of terracettes and may occur in columnar clay, loess, stratified silts, sands and fine gravels or wherever conditions are favorable to sliding. Dr. Sharpe tells of various methods of treatment to prevent and check the slide of slump—lowering water content of mass by drainage, artificial freezing of slide, rip-rap fills, artificial drying with hot air blown through a system of drilled holes, concrete casings (in weak shale bedrock) walls and fences, spraying with heavy oil or gunite to keep out water.

In conclusion, Dr. Sharpe presents an ingenious diagrammatic classification of landslides and related phenomena, and brings together the types of mass-movements to show that they form "a continuous series, grading from mass-movement of dry earth or rock into mass-transport by fluvial and glacial processes." A classified bibliography lists 275 selected references "dealing with general principles and * * * describing individual types of flow and slide phenomena."

EXPERIENCE WITH STRIP CROPPING

(*Continued from p. 107*)

diverted acreage. She produced 19 bales of cotton from 24 acres, 800 pounds of milo grain from 27.8 acres, and let the Sudan remain on the field for protection against wind erosion and to check run-off water. In 1936, this field had produced only 8 bales of cotton on 30 acres and 600 pounds of milo on 29.8 acres.

These results indicate that strip cropping is a practical and inexpensive method of permitting the safe use of fallow and profitable nonerosion-resisting crops. This practice definitely has a place in a well-coordinated program of soil and moisture conservation for prevention of soil drifting and at the same time facilitates a well-balanced system of farming whereby forage crops can be produced on the farm each year.

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